UNTOLD VALUE:

Nature's Services in Washington State

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Asia Pacific Environmental Exchange

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EXECUTIVE SUMMARY

Washington State's fish and wildlife habitats, including marine shorelines, wetlands and streams, provide many tangible and intangible benefits to residents of Washington. These benefits, called ecological services, include everything from flood control to water filtration to provision of recreational opportunities.

When ecological services are lost through inadequate planning, taxpayers and governments incur significant costs to replace these services. Some services can be only partially replaced, and some can never be replaced by any amount of dollar investment.

As humanity increasingly grasps its profound dependence on ecological services, economists are developing more sophisticated ways to measure the value produced by ecosystems. The knowledge generated by such techniques is important for informed land use planning.

Studies conducted to date on the value of ecological services produced by fish and wildlife habitat in Washington State indicate that such habitat is producing ecological services worth many billions of dollars annually. These studies underestimate the true value generated by ecological services as many ecological services have not yet been valued, or have been valued incompletely. In addition, some of the value produced by ecological services cannot be expressed in dollar figures.

Nonetheless, though underestimates, these studies indicate that the ecological services produced by fish and wildlife habitat in Washington have real, quantifiable value. This value ranks on par with, or exceeds, the value generated by many of Washington's key industries. This high relative magnitude of value makes sense because at root, ecological services produced by habitats play a crucial role in making life possible in Washington State and beyond. Breathable air is one example. The oxygen that sustains us is produced almost exclusively by plant life, plant life that exists because viable habitats remain. Life without oxygen is unimaginable.

Ecological services provide an indispensable complement to the human-created economy. As a result, intelligent land use decisions cannot be made without taking into account the services produced by ecosystems.

INTRODUCTION

This document provides an overview of existing knowledge on the value of ecological services produced by fish and wildlife habitat in Washington State. It begins with an introduction to the concept of ecological services and ecological service valuation methods. It then provides an overview of the studies that have been conducted to date on the value of ecological services produced by marine shoreline and terrestrial habitats in Washington State. It ends with a summary of this data and conclusions.

NATURE'S SERVICES

Nature provides the life support system for all life on Earth. The Earth's natural processes provide a climate in which plants can grow, shield us from the deadly ultraviolet rays of the sun, produce oxygen, provide water, and support us in dozens of other ways. The economy, like all human systems, also depends on the Earth. The Earth acts both as a source of the raw materials needed by the human economy and a sink for its wastes. In addition, the economy depends on the intricate natural processes that keep our planet livable.

Over the last few decades, scientists have become increasingly aware of humanity's dependence on natural systems. In 1997, a group of internationally-renowned scientists led by Stanford scientist Gretchen Daily published a book describing the ways that natural systems sustain human societies. In the book, *Nature's Services*, Daily defined ecological services as "the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life" (Daily 1997). As Chart 1 indicates, these services include everything from climate regulation to pollination.

Table 1. NATURAL SERVICES
Purification of the air and water
Mitigation of floods and droughts
Detoxification and decomposition of wastes
Generation and renewal of soil and soil fertility
Pollination of crops and natural vegetation
Control of the vast majority of potential agricultural pests
Dispersal of seeds and translocation of nutrients
Maintenance of biodiversity
Protection from the sun's harmful ultraviolet rays
Partial stabilization of climate
Moderation of temperature extremes and the force of wind and waves
Support of diverse human cultures
Providing of aesthetic beauty

Source: Daily 1997

Also in 1997, the value of a partial list of the Earth's ecological services was estimated by an additional group of distinguished academics led by Robert Costanza, then of the University of Maryland. The study estimated that the average annual value produced by the Earth's ecological services was thirty-three trillion dollars. This amount significantly exceeded the world's total Gross Domestic Product at the time (Costanza et al. 1997).

This research confirmed that both human-made capital and ecological services contribute significantly to human welfare. Given this relationship, decision-making that overlooks the value of ecological services may leave us worse, not better, off.

VALUING NATURE'S SERVICES

Economics has advanced in the last 20 years, and the methods, tools, and techniques for measuring the value produced by natural systems have improved greatly. It is now clear that natural capital is of tremendous value.

Not all easily-identified ecological services can be expressed in dollar figures. In addition, many ecological services may not yet be identified and value to future generations is not counted. As a result, dollar estimates of the value produced by natural systems are inherently underestimates. For example, while we may be able to place a dollar value on the water filtration services provided by a forest, we cannot fully capture in dollars the aesthetic pleasure humans gain from looking at the forest, nor every aspect of the forest's role in supporting the intricate web of life.

There are always many values we can name but for which we cannot establish prices or costs. Thus, ecological service valuations are not intended to capture all value, but rather to serve as markers below the minimum value of the true social and ecological value of an ecological service.

However, when societal tradeoffs are being made, these markers remind us that the value held in ecological services is significantly higher than zero. As Robert Constanza and Carl Folke have noted, "[w]e cannot avoid the valuation issue, because as long as we are forced to make choices we are doing valuation" (Costanza and Folke 1997).

Because the remainder of this document discusses the studies conducted to date on ecological services in Washington State, it is helpful to begin with some background on valuation of ecological services. The next few paragraphs provide that background.

Valuation of ecological services

An ecological service is referred to as a "service flux," which means in part that its productivity is measured as output per unit of time. Healthy, intact ecosystems are self-organizing, providing valuable ecological services on an ongoing basis ("in perpetuity") at no cost to humans. The delivery of ecosystem services depends on maintenance of a specific arrangement of ecosystem components—on maintenance of a particular "structure." An example of the concept of structure is a car. A car provides a flow of service, but this service is dependent upon a particular arrangement of the parts of the car—on a particular structure. In this way, yields of ecological services ("service fluxes") such as pollination, or water filtration, are distinct from "resource flows," like timber extraction. For example, where as a single-species timber plantation might yield resource-flows such as wood for extraction, the timber plantation would not provide the same service-fluxes as a largely intact natural forest ecosystem. Specifically, service fluxes such as mitigation of floods, decomposition of wastes, renewal of soil, pollination, pest control, translocation of nutrients, and provision of habitat are not yielded by a timber plantation to the same degree as by a natural forest ecosystem. When it comes to generation of ecological services, the elements of the ecosystem, and their relationship to each other, matter.

To describe ongoing fluxes of ecological services, scientists and economists often describe the service-flux in terms of the dollar value it generates per unit of area over a given time period. In order to standardize the language in which ecological services are described, researchers are increasingly expressing the value yielded by ecological services in dollars per hectare per year (De Groot et al. 2002). One hectare is equivalent to 2.471 acres (Metric Conversions n.d.).

However, because many of the studies referred to in this document were conducted before researchers began working to standardize measures of ecological services, many of the studies cited do not refer to ecological service values in these units. As a result, comparison of the various values is more difficult, as is assessing the relationship between the dollar value cited and the time period over which the ecological service benefits were provided. Such is the nature of an evolving science, however. The values cited here still serve to indicate that quantifiable value is present where we have previously often not recognized it.

It is also important to note that value is not fixed in time. The values of many ecological services are increasing as they become increasingly scarce (Boumans et al. 2002).

Valuation techniques

The valuation techniques used to value ecological services were primarily developed within environmental and natural resource economics, branches of traditional economics. They involve a variety of approaches to valuing natural services. These include: direct market pricing, replacement cost, avoided cost, factor income method, travel cost, hedonic pricing, and contingent valuation. These techniques are discussed in Appendix 1. The majority of the valuation techniques used in the studies referenced in this document involve direct market pricing, replacement and avoided costs, and travel costs. In a few cases, contingent valuation figures are used.

THE VALUE OF WASHINGTON STATE'S COASTAL HABITATS

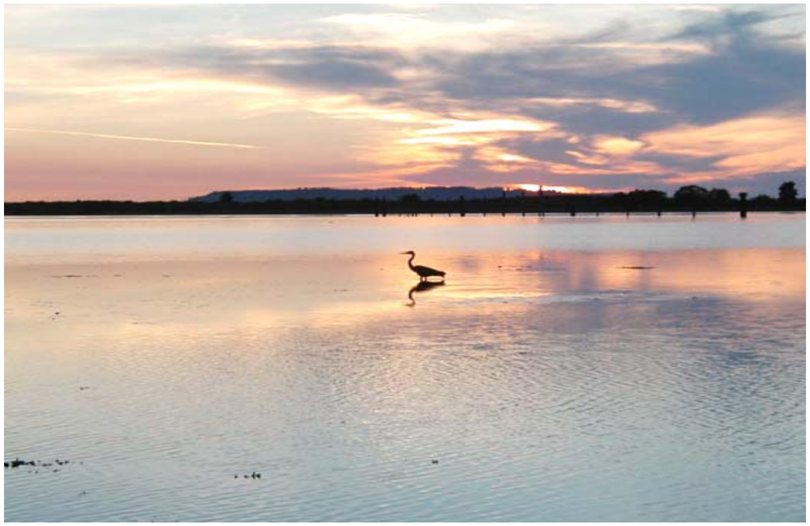
Coastal ecosystem services provide a significant contribution to human welfare on the planet. Noting that the coastal zone accounts for only 6.3% of the Earth's surface, Costanza and fellow researchers indicated that the value of the services provided by the coastal zone amount to approximately 43% of total global ecosystem service value (Costanza et al. 1997). In addition, because we do not yet fully understand all of the dynamics of natural systems, especially marine and coastal systems, this could be an underestimate.

Washington State's coastal shorelines can be expected to exhibit a similarly disproportionate level of productivity. Washington State has three "coasts" – the shores of the inland marine waters of Puget Sound and the Strait of Juan de Fuca (2,246 miles); the Pacific Ocean coast (171 miles); and the shores of the estuaries fronting the Pacific Ocean (313 miles) (Hagen 1958). Washington State's shoreline includes eelgrass meadows, kelp beds, rocky shores, salt marshes, beaches and tidal flats home to numerous species of economic and ecological value. It provides a treasure chest of genetic resources, helps to regulate weather and diffuse storms, and plays an important role in nutrient cycling. Some of these services are well-documented in economic terms and others have yet to be measured.

Lending refuge to fish and wildlife

One of the important services provided by Washington's shoreline is the refugium and nursery ecological service function. The refugium function is defined as the function of providing "suitable living space for wild plants and animals" (De Groot et al. 2002). The nursery function is defined as the function of providing "suitable reproduction habitat [for wild plants and animals]" (De Groot et al. 2002).

The Washington State shoreline provides habitat to over 200 species of fish, 26 types of marine mammals, 100 species of sea



Everett Shoreline Coalition

birds, and thousands of marine organisms (Puget Sound Action Team 2003). While data do not yet exist on the dollar value of the refugium and nursery service function of the Washington State shoreline, these services are closely linked to dollar figures associated with other ecological services, such as recreation, commercial fishing, and tourism, as is discussed in the sections below. The values for the ecological services of recreation, commercial fishing and tourism discussed in the paragraphs to follow are in part dependent on the refugium function. For example, the income generated by the salmon catch of fishermen, or by the whale watching industry, is dependent upon the continuing viability of the refugium service that sustains salmon and orca whales, and thus provide an indirect indication of its value.

State and federal expenditures on salmon habitat restoration are an additional indirect indicator of the value of the refugium function. State funds appropriated for salmon recovery in 2001-2003 totaled $28.3 million while federal funds for Washington State salmon recovery in the 2000-2002 biennium exceeded $101 million (Washington State Department of Fish and Wildlife [WDFW] 2002). The willingness of the state and federal government to spend more than a hundred million dollars on salmon recovery indicates that this single species, and by extension, its habitat are valued in the Pacific Northwest. The magnitude of the funds involved also illustrates the costs incurred when healthy ecosystem functions are lost.

A study in Oregon provided a third indication of the value of the ecological service provided by the refugium function. In a study of estuarine function, residents of the Tillamook, Oregon area estimated the value of each additional acre of salmon habitat at approximately $5000 (Gregory and Wellman 2001).

Providing recreation and tourism opportunities for residents and visitors

The fish and wildlife sector is a major economic force in Washington. Approximately one billion dollars are spent annually on recreational fishing alone, while an additional $1.3 billion is spent annually on wildlife viewing and $408 million on hunting (WDFW 2002). Commercial fishing generates $289.2 million annually in Washington (WDFW 2002). This economic contribution equals or surpasses other industries traditionally perceived as Washington's economic base. Wildlife watching alone generates significantly more revenue for Washington's economy than the apple industry and supports over 21,000 jobs in the state, more than any Washington employer other than Boeing (WDFW 1997). In addition, fish and wildlife habitat cannot leave Washington State. Salmon will not migrate to Chicago, or China.

Generating tourism dollars

Washington's shoreline, including the Puget Sound estuary, is also a significant driver of tourism revenues. According to a study by Portland-based Dean Runyan & Associates, business and leisure travelers in 2001 spent an estimated $10.8 billion visiting Washington State (Puget Sound Business Journal 2002). The Puget Sound region generates approximately 80% of statewide tourism revenues and 75% of tourism-related jobs (Puget Sound Action Team 2003).

Doug Collins

Lending aesthetic beauty that attracts workers and firms

Many of the high technology and manufacturing companies that contribute to the economic base of the Washington economy locate in the Puget Sound region in part because of the quality of life the region supports. This quality of life is partially the result of ecological services, such as the provision of aesthetic beauty. In a recent consensus letter, dozens of economists including Nobel Laureates Kenneth Arrow and Robert Solow noted that environmental quality today plays a pivotal role in the ability of a region to attract workers and firms. The economists stated that:

> [t]hose who believe environmental degradation is an unavoidable price to pay for economic prosperity in the West are wrong. Across most of the West, a community's ability to retain and attract workers and firms now drives its prosperity…if a community's natural environment is degraded, it has greater difficulty retaining and attracting workers and firm (Whitelaw 2003).

Though no study quantifies the contribution of aesthetic beauty to the region's economic base, there is strong evidence that such a contribution exists.

Providing genetic resources

The genetic diversity held in plants, animals, and microorganisms provides significant benefits for food production and health care. In many cases, these benefits are currently given no economic value, though they contribute greatly to social welfare. For instance, marine organisms, having developed complex chemical systems and survival skills to cope with extreme living environments, have contributed to several scientific advancements. Arabinosides, for example, extracted from the Caribbean sponge, Tethya crypta, led to more than $50 million in annual sales from antiviral medicines (NOAA 2004). Though the Puget Sound is rich in biodiversity, our present understanding of these resources, and their potential applications, is microscopic.

Other ecological services

Additional ecological services provided by Washington's shoreline ecosystems include carbon storage, atmospheric gas regulation, nutrient cycling, diffusion of coastal storms, and waste treatment.

The value of these services is unknown but likely significant. These services are important contributors to the total value of services contributed by coastal ecosystems, the total global value of which was conservatively valued at $11.7 trillion per year in 1997 (Costanza et al. 1997).

The value of the services provided by Washington's shoreline ecosystems

Currently, valuation data regarding the services provided by global coastal systems are scarcer than valuation data describing terrestrial ecosystems. This is also the case with the ecological services generated by Washington's shoreline ecosystems. However, even the limited figures available indicate the great value that marine and estuarine services generate. Expressed in 2004 dollars, the total for shoreline-related recreation and tourism alone is in the range of $10 to $14 billion. This figure does not include the value of the numerous additional services also provided by Washington's shoreline, including the refugium function, disturbance regulation, carbon storage, nutrient cycling, waste treatment and provision of genetic resources.

THE VALUE OF AQUATIC AND TERRESTRIAL FISH AND WILDLIFE HABITATS IN WASHINGTON STATE

Non-marine habitats in Washington State also generate significant value. The section that follows considers three main habitats: wetlands, forests, and other fish and wildlife habitat. For each of these, key ecological service functions are discussed, along with the studies that indicate their value.

Costanza and colleagues estimated that approximately 38% of the estimated total global ecological services result from land-based ecosystems, primarily from wetlands ($4.9 trillion/year) and forests

($4.7 trillion/year) (Costanza et al. 1997). Washington's wetlands and forests also yield considerable value.

Ecological services of wetlands in Washington

Wetlands provide a host of benefits and services of ecological and economic benefit to communities.

Providing habitat for fish and wildlife

The refugium function of wetlands is an especially important one. Nationally, forty-three percent of federally-listed threatened and endangered species rely directly or indirectly on these critical areas for their survival (EPA 2003). This figure is expected to also be significant in Washington State.

Preventing damage from floods

A Washington State wetlands study assessed the value of flood protection in two Washington cities. The study found that wetlands in Lynnwood yielded a flood protection benefit worth between $7800/acre and $51,000/acre, while Renton wetlands yielded a flood protection benefit of $41,300/acre to $48,200/acre (Leschine et al. 1997). Similarly, a draft study conducted in Portland indicates that creation of a wetland to prevent flooding in a frequently flooding area of Southeast Portland would prevent damage amounting to more than $500,000 per flood. This figure is based on actual damages to local homeowners in previous floods in the area (Rojas-Burke 2004).

Wetland Ecological Services
Ground water recharge
Improved water quality
Habitat for aquatic, terrestrial and avian species
Nutrient cycling
Biomass production
Flood control
Stabilization of sediment
Ground water recharge
Improved water quality

Source: Woodward and Wui 2001

Removing pollutants

Other regions in the country have conducted valuations on other ecological services provided by wetlands. A 1990 study found that the 11,000-acre Congaree Bottomland Hardwood Swamp in South Carolina removed the same amount of pollutants as the equivalent of $5 million waste water treatment plant (EPA 2003). A study in Georgia revealed that a 2,500 acre wetland saves taxpayers $1 million in water pollution abatement costs (EPA 2003). While the exact values of these services may differ in Western Washington, it is expected that these services have significant value here as well.

Raising property values through aesthetic and recreational services

Wetlands also serve aesthetic and other functions for humans. Property values are one indicator of the aesthetic and recreational services provided by wetlands. For example, a study in the Portland area found that residential property values increased if they were closer in proximity to wetlands. For every 1,000 feet closer a property was to wetlands, the property's value increased by $436 (Mahan et al. 2000).

Ecological services of forested land in Washington

Significant fish and wildlife habitat in Western Washington consists of forested lands adjacent to, or close to, currently developed areas. Such forested lands provide valuable ecological services.

Filtering drinking water

One important service provided by forests is water filtration. To avoid the need to build a $200 million water filtration plant and pay to operate it, Portland spends $920,000 annually to protect its Bull Run watershed, thus maintaining natural filtration of its drinking water supply (Krieger 2001). Annual operating costs of artificial water filtration plants vary. Estimated annual operating costs of a water filtration facility in Portland, Maine were $750,000. In contrast, they were $3.2 million for a facility in Salem, Oregon, and $300 million for New York City (Krieger 2001).

Regulating the climate and cleaning the air

In a period where climate change is a realized issue, forests provide climate regulation at a value of $35 per acre (Loomis and Richardson 2000). This figure is based on the market for carbon sequestration. Economic research also indicates that forests provide environmental purification and recovery of mobile nutrients—waste treatment services—valued at an additional $35 per acre (Loomis and Richardson 2000). According to Washington state officials, if logged forests in the Puget Sound region had been kept intact, they would have absorbed approximately 35 million additional pounds of air pollutants per year since 1972, providing a service worth almost $95 million (Wilderness Society 2001).

Capturing storm water

Over 10,000 acres of forest lands were lost annually due to urban development in the Puget Sound between 1980 and 1990 (MacLean and Bolsinger 1997). These low-lying forests provided a valuable stormwater system at no cost to taxpayers. Today, it is estimated to cost $15 to $150 per acre to comply with Phase II of the EPA process of stormwater regulation (Treadway and Reese 2000).

Controlling pests

Natural systems keep a wide variety of pests in check. Estimates indicate that it would cost more than $7 per acre to replace the pest control services provided by birds in forests with chemical pesticides (Krieger 2001). In addition, these natural pest control services are even more valuable as compared to chemical pest control methods than these figures capture, as they do not include the high associated costs of toxic loading.

Genetic resources

Out of the total quantity of prescription drugs administered in the United States today, approximately 25% contain active ingredients that originate from higher plants (Mazzotti 2004). (Higher plants are those that have true roots, stems, and leaves, as well as developed vascular systems [Columbia Encyclopedia 2003]). The breast cancer drug taxol, for example, was produced from the bark of our native Pacific yew tree (Earth and Sky Radio Series 2000).

Supporting the advance of scientific knowledge

It is estimated that each scientific article resulting from study of natural environments contributes a value of $12,000—over $5 million annually—to the advancement of the goals and interests of humanity (Loomis and Richardson 2000). This estimate indicates the interconnection between scientific research and environmental protection.

Supporting quality of life and other human values

Studies of household values routinely reflect strong preferences for protection of forests, fish and wildlife. Olsen and others (1991) found that households in the Pacific Northwest were willing to pay between $26 and $74 per year to double the size of the salmon and steelhead runs in the Columbia River (Quigley 1997). Another study found that Oregon households were willing to pay $2.50 to

$7.00 per month to protect or restore salmon, a cumulative total of $3 to $8.75 million dollars per month (ECONorthwest 1999).

The mean annual value per household of river and fishery restoration on the Olympic Peninsula was $59 dollars in Clallam County and $73 for the rest of Washington (Loomis 1996). Another study found Oregon households willing to pay $380 annually to increase old growth forests, $250 per year to increase endangered species protections, and $144 to increase protection for salmon habitat (Garber-Yonts et al. 2004).

Jerry Gorsline, Hoh River Bog

Ecological services of other fish and wildlife habitat types

Other fish and wildlife habitat types in Western Washington include grasslands; lakes, rivers and reservoirs; agricultural land and pasture; and urban green spaces. There are not good figures for the ecological services values provided by all of these lands in Washington. In general, however, the most developed environments provide the fewest ecological services. By way of comparison, a recent ecological services valuation in Massachusetts indicated that 85% of the value created by ecosystem services was generated by wildlife habitat – wetlands, forest, and water bodies – in contrast to land that had been altered by development (Breunig 2003).

THE ECONOMIC VALUE OF SERVICES PROVIDED BY WASHINGTON'S MARINE AND TERRESTRIAL ECOSYSTEMS: THE BOTTOM LINE

Washington State's ecological systems generate great value—the research summarized in this document indicates that Washington alone produces several billion dollars in ecological services annually.

While the figures in this report cannot be strictly summed, it is worth reviewing the numbers presented here, all of which are direct or indirect financial indicators of the value of fish and wildlife habitat in Washington:

- Well over $100 million in federal and state funding for salmon recovery in Washington State between 2000 and 2003.
- Residents of Oregon estimated the value of each additional acre of salmon habitat at approximately $5000.
- Approximately $1,000,000,000 is spent annually on recreational fishing in Washington.
- An additional $1,300,000,000 is spent annually on wildlife viewing.
- Commercial fishing generates $289.2 million annually in Washington.
- In 2001 travelers spent an estimated $10.8 billion visiting Washington state.
- The Puget Sound area generates approximately 80% of statewide tourism revenues.
- Wetlands in Western Washington provide a flood protection benefit worth between $7,800 and $51,000 per acre.
- In Washington's neighbor city of Portland, property values increase by $436 with every 1,000 feet of additional proximity to wetlands.

- Forests provide a carbon sequestration service worth $35 per acre.
- Forests also remove additional pollutants from the air, generating a service worth an additional $35 per acre.
- Removal of low-lying forests is linked to increased stormwater costs. Compliance with Phase II of the EPA storm water regulation process is estimated to cost between $15 to $150 per acre.
- Artificial water filtration plants to replace natural water filtration services can cost $200 million or more to construct, and also necessitate additional expenditures to cover operating costs.
- To replace the natural pest control services provided by birds in forests would cost an estimated $7 per acre.
- Each scientific article derived from the study of natural environments is estimated to contribute an average of $12,000 to the advancement of humanity's interests.
- Households in the Pacific Northwest indicate a willingness to pay between $26 and $250 per year to protect fish species such as salmon and steelhead.
- Studies in other states have found that 85% of the value generated by ecological services was generated by natural wetlands, forest, lakes and rivers, and shorelines, as opposed to land that had been altered by development.

These figures indicate that ecological services provided by fish and wildlife habitat in Washington State are generating value worth at least several billion dollars annually. This number is guaranteed to be a vast underestimate as some ecological services cannot be valued, the list of ecological services valued above is an incomplete one, and scientific understanding of the full range of services humans derive from ecosystems is incomplete.

Intact ecosystems in Washington State provide an extremely valuable basket of ecological services for free and in perpetuity. If we damage these ecosystems, it will cost us, be it in additional water treatment, flood control, storm water management, and water filtration costs, or reduced property values, tourism and recreation revenues, or the costs associated with an unpredictably shifting climate or dirtier air. All of these costs harm taxpayers and governments or erode quality of life. Even when ecological services can be partially replaced through a human-made system, the full range of services formerly provided by a functioning ecosystem cannot be recreated.

Even this preliminary compilation of ecological service values indicates the need to develop with a greatly increased degree of care. Although current data and methods only enable us to glimpse a small portion of the total value provided by natural systems in Washington, this glimpse is sufficient to set us on notice of our previous tendency toward blind destruction. Evolving research and improved techniques will likely shine additional light on the ways in which, and the degree to which, ecosystems support human well-being. Such improved knowledge will enhance our ability to make informed choices about the trade offs involved in development regulation. Growth in human-produced capital does not occur in a vacuum but rather often comes at the cost of lost ecological capital.

In the meantime, we are likely best served by precautionary approaches. The precautionary principle states that in the face of uncertainty, it is preferable to take actions to avert potential serious harm. In essence, the precautionary principle captures the common sense notion that it is better to be safe than sorry. Without precaution, we will destroy what we do not yet fully understand, harming ourselves and other present and future inhabitants of the Earth in ways that we cannot yet fully predict or even perceive.

FURTHER RESOURCES

Ecological Economics

Two centuries of incomplete economic accounting has eroded crucial ecological systems that all humans depend on for life. The economic rules we use today were first described around 1790 by Adam Smith. In 1790, the population of the Earth was around 700 million people. The industrial revolution was just beginning. Natural capital was abundant and the science of ecology did not yet exist. Economics sought to address the problem of the scarcity of human-produced capital.

Today, the population of the Earth exceeds six billion people. Science has given us an improved appreciation of our dependence on natural systems. Human produced capital (such as fishing boats) is today relatively abundant while natural capital (such as fish in the sea) is becoming increasingly scarce. To a large degree, however, our economic system is still operating to solve the problems of the 1790s.

To address the need for updated economic tools, a group of economists and other thinkers founded the discipline of ecological economics. Ecological economics integrates multiple disciplines to create more sophisticated, accurate and useful economic tools better suited to addressing modern challenges, such as ensuring a high quality of life for all people and protecting the ecological systems we all depend on.

As the size of the economy has expanded relative to the size of the global ecosystem that sustains it, science indicates that the "source" and "sink" functions of the global ecosystem are increasingly stressed. For example, humans are displacing a large percentage of the total biomass available on the planet and have overfished to such an extent most global fisheries are now in a state of decline or collapse. Our wastes are raising the temperature of the globe, eroding the ozone shield, and contaminating our bodies with toxic chemicals.

In the transition from an "empty" to a "full" world, humanity is discovering that the economy does not expand into a vacuum but instead expands at the expense of ecological services crucial to human well being. Since the root goal of economics is to provide human welfare, ecological economics incorporates into its measure of efficiency the recognition that human welfare is provided by both ecological services and human-made capital. This measure, called comprehensive efficiency, is the ratio of services flowing from the human-made capital stock to the services sacrificed from the natural capital stock as a result. This definition reflects the trade off between services gained and services lost as the economy grows.

Ecological economics argues that we should seek to derive as much value as possible out of the combination of human-produced and natural capital. In essence, we need better development not catastrophic development.

For more information on ecological economics, see the APEX website (www.a-p-e-x.org). In addition, APEX offers skillshares, or mini-trainings, that introduce ecological economic concepts. Contact APEX for more information (eco-econ@a-p-e-x.org; 206-652-8413).

For more information on how you can promote sound development practices in your community, contact:

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APPENDIX 1: ECOLOGICAL SERVICE VALUATION METHODS

Direct market pricing
In some cases, the value of natural services is priced in the market system. For example, in the case of carbon sequestration by forests, a market has been established and hence a market price exists. Every ton of carbon removed from the atmosphere commands a value on the market. This is called direct market pricing.

Replacement cost method
The value of some other services can be measured based on their replacement cost. For instance, this technique involves looking at the amount society will have to pay to filter drinking water with a human-made system if the water filtration function of a forest is lost. Such costs can often be quantified due to information on government expenditures on water filtration systems and other such infrastructure items.

Avoided cost method
A related valuation method is the avoided cost method. This method involves valuing an ecological service based on the costs that society avoids by having the ecological service intact. For example, healthy wetlands reduce flooding and thus flood damages such as property damages. Because wetlands also produce many other benefits beyond flood control, such a measure provides an underestimate of the full value of wetlands.

Factor income method
Another valuation method is called the factor income method. Some ecosystem services enhance income. This income enhancing effect can be used to derive a value for the service. For instance, the factor income method can be used to calculate the value of higher water quality linked to financial returns of commercial oyster harvesters. This is an underestimate of the true value of cleaner water, because cleaner water also produces additional benefits.

Travel cost method
Travel cost is another ecological service valuation method, often used to calculate recreational values. If a person travels to use a particular ecological service, the cost of travel is an indicator of the implicit value the traveler placed on the ecological service. A person who traveled to utilize a particular recreational resource must have valued the services provided by the resource at least as much as what they paid to travel to it. This is also an underestimate of the true value because it is likely that the recreational experience was worth more than the gas money and other expenditures associated with arriving at the site of the recreation activity.

Hedonic pricing
An additional valuation technique is hedonic pricing, where demand for an ecological service is reflected in the prices people will pay for goods associated with the service. For example, the aesthetic value of a beach is partially measured by the differential in prices of housing with a view of the beach in comparison to comparable properties without a view. However, this also is only a partial valuation. The actual aesthetic value of the view exceeds the dollar differential between the properties because people who do not purchase property also enjoy the view. Thus hedonic pricing of the beach gives us a clear dollar value for the aesthetic value of the beach, but we know that value is below the total aesthetic value.

Contingent valuation
A final method involves contingent valuation. In this case, survey techniques are used to evaluate individuals' willingness to pay for a particular service. This method also has biases that preclude it from measuring the full value.

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